
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Genetic and phenotypic relationships between flystrike indicator traits in a stud Merino flock

D.R. SCOBIE[1]*, S.M. HICKEY[2], D.P. MASLEN[3] and the late G.M. BLACK[4]

[1]AgResearch, Lincoln, Private Bag 4749, Christchurch 8140, New Zealand
[2]AgResearch, Ruakura, Private Bag 3123, Hamilton 3240, New Zealand
[3]The New Zealand Merino Company Limited, P.O. Box 25-160, Christchurch, 8144, New Zealand
[4]Awapiri Station, Private Bag 1205, Blenheim 7240, New Zealand
*Corresponding author: david.scobie@agresearch.co.nz

ABSTRACT

Increasing breech wrinkles, breech cover and dags increase flystrike susceptibility of Merino sheep. Urine stain has been implicated in flystrike, although there is a paucity of data. At tail docking in 2007, 2008 and 2009 on a property breeding Merino rams, breech wrinkle (1 to 5) was scored on 238, 202 and 337 lambs that were the progeny of 12, 9 and 9 sires respectively. Dag score (0 to 5), urine stain (0 to 5) and breech cover (1 to 5) were scored at 100 days of age. Breech wrinkle score (h^2 = 0.51 ± 0.11) and breech cover (h^2 = 0.27 ± 0.08) were heritable, and phenotypically (0.16 ± 0.04, P <0.05) and genetically correlated (0.77 ± 0.14, P <0.05). Dag and urine stain scores were skewed towards low scores and the heritability estimates for these traits were low (h^2 = 0.08 ± 0.07 and 0.04 ± 0.06 respectively). Yearling clean fleece weight was heritable (h^2 = 0.28 ± 0.13) and genetically correlated with breech cover (-0.62 ± 0.26, P <0.05). There was no evidence of flystrike during the investigation, but there was potential to decrease susceptibility by decreasing breech cover and breech wrinkles in this flock.

Keywords: ribby pelts; body wrinkle; breech strike.

INTRODUCTION

The presence of wrinkles on the breech of Merino sheep is known to increase susceptibility to flystrike (James, 2006; Scholtz *et al.,* 2010a,b). The formation of dags also increases the risk of flystrike in many breeds of sheep (Leathwick & Atkinson, 1995; 1996; Scobie *et al.,* 2002; James, 2006). Inherited breech bareness can reduce the formation of dags (Scobie *et al.,* 2008) and reduce the risk of flystrike (Scobie & O'Connell, 2010). Although the presence of urine stain is anecdotally implicated in flystrike, surprisingly there is a paucity of scientific reports connecting flystrike with urine staining. Recent experiments in Australia have examined the relationship between these traits and also with flystrike (Greeff & Karlsson*,* 2009; Greeff *et al.,* 2010; Smith *et al.,* 2009). The genetic and phenotypic relationships between the extent of urine staining and other traits implicated in the risk of flystrike were investigated on a stud New Zealand Merino flock during a three year period.

METHODS

A flock of stud sheep at Awapiri Station in Marlborough were observed across a three year period. An important feature of this flock was that it was commercially farmed and as such, animals were occasionally removed by culling for body conformation and visually assessed fleece traits as lambs and yearlings. Ewes were single-sire mated each year to a total of 21 sires. The number of sires ranged from 12 in 2007 to nine in both 2008 and 2009. Two sires were used repeatedly across each of the three years, and five other sires were used in two consecutive years. Some groups were mated by artificial insemination. Lambs were tagged at birth and all had sire and dam recorded. The number of progeny from each sire varied from four to 75 due to variable numbers of ewes mated to each sire. A total of 238 progeny were recorded in 2007, 202 in 2008 and 337 in 2009. Pedigree information was obtained from stud records.

Mixed sex progeny were scored for breech wrinkles at tail docking. A score of one was given to an animal with no evidence of skin wrinkling and a score of five to an animal that was excessively covered in wrinkles around the breech.

The progeny were shorn as lambs and again as yearlings at around 365 days of age when they were carrying nine months of wool growth. The yearling fleeces were weighed and fleece samples taken and measured for washing yield and fibre diameter. Clean fleece weight was calculated from multiplying the greasy fleece weight by the washing yield. The progeny were also scored for breech cover at yearling shearing. It is important to note that for anyone familiar with similar work on New Zealand crossbreds (Scobie *et al.,* 2007; 2008; Scobie & O'Connell, 2010) that breech cover score is the opposite of breech bareness score. Sheep Genetics Australia uses breech cover (Australian Wool Innovation, 2007) whereas Sheep Improvement Limited in New Zealand uses breech bareness (Walker & Young, 2009).

TABLE 1: The number of single and twin lambs in each sex and breech wrinkle score group at shearing.

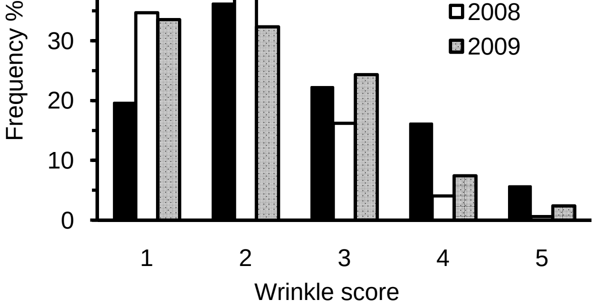
Breech wrinkle score	Ram lambs		Ewe lambs	
	Single	Twin	Single	Twin
1	31	58	67	59
2	64	34	68	48
3	50	27	56	31
4	30	4	35	11
5	8		11	5

TABLE 2: Live weight (kg) at yearling shearing of rams and ewes born as singles or twins and grouped according to their breech wrinkle score at tailing. Standard deviation of average live weight in birth rank grouping indicated in parentheses, which along with the mean, were calculated from raw data.

Breech wrinkle score	Ram lambs		Ewe lambs	
	Single	Twin	Single	Twin
1	35.0	34.0	31.9	30.5
2	38.5	33.0	32.6	29.2
3	37.9	36.5	32.6	29.5
4	43.2	31.7	32.2	34.3
5	37.7		33.8	
Average	38.3 (± 3.4)	34.0 (± 3.9)	32.5 (± 5.3)	30.1 (± 4.9)

The progeny were scored for dagginess, and urine stain at yearling shearing. A dag score of 0 was given to an animal with no evidence of dags and a score of 5 was allocated to animals on which there were extensive dags covering the breech region. The six point dag score scale used here was originally developed by Larsen *et al.* (1994). Urine stain was scored on a similar basis but using a five point scale (Australian Wool Innovation, 2007). Urine stain scoring was applied to female progeny only (n = 389).

FIGURE 1: Percent frequency of progeny (Frequency %) in wrinkle score groupings 1 (no wrinkles) to 5 (excessively wrinkled) at tailing in each of the three years of investigation.



No animals were flystruck on this stud during the three year period of observations.

Heritabilities, genetic and phenotypic correlations were estimated for clean fleece weight, fibre diameter, breech wrinkle score, urine stain score, breech cover score and dag score using animal-model restricted maximum likelihood (REML) procedures (Gilmour *et al.,* 2009) with a relationship matrix including seven generations of pedigree information. The fixed effects were a contemporary group combining birth year and sex, and birth rank (1-3). Heritabilities and correlations were obtained from both five-trait, excluding fibre diameter, and four-trait, excluding clean fleece weight and dag score, REML analyses.

RESULTS

The percentage of lambs in each of the breech wrinkle scores at tailing is shown across the three years in Figure 1. This frequency distribution shows a large proportion of lambs in the plain breech scores and very few in Score 4 and Score 5. There was a tendency towards a reduction in the number of lambs with wrinkly breeches with a Score of 4 or a Score of 5, during the course of the project as the selection of sires was influenced by the information collected in this and other studies.

The numbers of lambs in each breech wrinkle score at shearing are shown in Table 1 and divided on the basis of sex and birth rank. Only 14 lambs were born as triplets and survived to weaning. Data for these lambs have been omitted from the tables, although this information was used in the genetic analysis. At tail docking, male lambs were less wrinkly ($P < 0.001$) with an average score of 2.0 ± 0.06 (standard error) than female lambs with a score of 2.3 ± 0.05. Twin lambs tended to be significantly less wrinkly ($P < 0.001$) (average score 1.8 ± 0.05) than single lambs (2.4 ± 0.06). There was no significant interaction between sex and birth rank for wrinkle score ($P = 0.83$).

Ewe and ram lambs were run separately following weaning, so the differences between sexes may be caused by environment. However, valid comparisons can be drawn between singles and twins within sexes. It must be noted again that as a commercial enterprise, many lambs had been sold by one year of age and culling could have biased these results. A total of 223 ewe lambs and 142 ram lambs remained on the farm. Rams were heavier than ewes ($P < 0.001$) at 365 days of age (Table 2), when twins were lighter than those born as singles in either sex ($P < 0.001$). Lambs with a greater wrinkle score also tended to be heavier. For example

TABLE 3: Mean, residual standard deviation (RSD) and coefficient of variation (CV%) for clean fleece weight (CFW), mean fibre diameter (FD), breech wrinkle score (Wrinkle), urine stain score (Urine), breech cover score (Breech cover) and dag score (Dag score).

Parameter	CFW	FD	Wrinkle	Urine	Breech cover	Dag score
Mean	2.59	17.3	2.22	1.47	2.67	0.92
RSD	0.35	1.18	1.02	1.08	0.87	0.76
CV%	14%	7%	46%	73%	32%	83%

TABLE 4: The estimated heritability ± standard error (in bold on the diagonal) and the correlations ± standard error between traits that indicate flystrike risk (phenotypic above the diagonal and genetic correlations below the diagonal) and clean fleece weight (CFW). The indicator traits were breech wrinkle score (Wrinkle), urine stain score (Urine), breech cover score (Breech cover) and dag score (Dag score).

Trait	Wrinkle	Urine	Breech cover	Dag score	CFW
Wrinkle	**0.51 ± 0.11**	0.36 ± 0.04	0.16 ± 0.04	0.02 ± 0.04	0.11 ± 0.06
Urine	0.87 ± 0.50	**0.04 ± 0.06**	0.01 ± 0.05	0.24 ± 0.06	0.16 ± 0.06
Breech cover	0.77 ± 0.14	0.89 ± 0.74	**0.27 ± 0.08**	-0.05 ± 0.04	-0.06 ± 0.05
Dag score	-0.07 ± 0.38	-0.61 ± 1.29	-0.27 ± 0.37	**0.08 ± 0.07**	0.03 ± 0.06
CFW	-0.35 ± 0.26	0.26 ± 0.58	-0.62 ± 0.26	0.57 ± 0.46	**0.28 ± 0.13**

TABLE 5: Clean fleece weight (kg) of yearlings previously shorn as lambs, grouped on breech wrinkle score, birth rank and sex. Standard deviation of average fleeceweight in birth rank grouping indicated in parentheses, which along with the mean, were calculated from raw data.

Breech wrinkle score	Ram lambs		Ewe lambs	
	Single	Twin	Single	Twin
1	2.08	2.45	2.79	2.60
2	2.68	2.39	2.89	2.50
3	2.54	2.48	2.76	2.41
4	2.44	2.51	2.96	2.80
5			2.83	2.85
Average	2.52 (± 0.39)	2.43 (± 0.27)	2.83 (± 0.37)	2.54 (± 0.30)

TABLE 6: Mean fibre diameter (μm) of yearlings previously shorn as lambs, grouped on breech wrinkle score, birth rank and sex. Standard deviation of average fibre diameter in birth rank grouping indicated in parentheses, which along with the mean, were calculated from raw data.

Breech wrinkle score	Ram lambs		Ewe lambs	
	Single	Twin	Single	Twin
1	16.2	16.7	17.8	17.7
2	17.6	17.0	17.9	18.2
3	17.1	17.5	17.9	17.3
4	16.4	17.2	17.3	16.2
5			18.8	17.8
Average	17.0 (± 1.3)	17.0 (± 0.3)	17.8 (± 1.2)	17.8 (± 1.1)

twin ram lambs with a wrinkle score of two were 5.5 kg lighter than singles with the same wrinkle score and twins grew less clean wool (Table 5) (2.4 versus 2.7 kg), while twin ewe lambs with a wrinkle score of two weighed 29.9 kg and grew 2.5 kgs of clean wool in comparison with single ewe lambs which weighed 32.5 kg and grew 2.8 kg of clean wool. The genetic analysis was thus adjusted for sex and for the penalty of being born as a twin.

Estimates of the genetic parameters are presented in Table 4. Wrinkle score and breech cover were moderately heritable in this flock, at a level similar to that of clean fleece weight. Only 24 animals were observed carrying dag scores of 3 or 4 and none expressed the maximum score of 5, with a preponderance of lambs that had a dag score of 0 (n = 489). Although urine stain score was expressed across the full range of scores from 0 to 5, it was only recorded in females and again few animals were observed with a urine stain score of 4 (n = 19) or 5 (n = 5) and a similarly low estimated heritability. Urine stain was positively correlated phenotypically with both wrinkle score and dag score but the genetic relationships were not significant.

An important relationship to note was that breech cover increased as wrinkle score increased. There was a strong positive genetic relationship (0.77 ± 0.14) although the phenotypic relationship was not as pronounced (0.16 ± 0.04). Likewise, as wrinkle score increased the amount of urine stain increased with an estimated genetic correlation of 0.87 ± 0.50 and phenotypic correlation of 0.36 ± 0.04.

One trait not included in Table 4 is fibre diameter, which is very important to Merino breeders. Fibre diameter measurements were not available for all yearlings born in the flock, so the genetic parameters have been calculated separately on a smaller subset of data (n = 376) (Table 6). In the Awapiri flock, fibre diameter averaged 17.6 ± 1.2 µm, and was highly heritable (0.73 ± 0.17). Fibre diameter represents a major factor in culling, and will have biased the data collected from this stud flock. There was no significant genetic correlation between fibre diameter and breech cover (-0.05 ± 0.22), but there was a strong and significant genetic correlation between fibre diameter and urine stain (0.84 ± 0.33), or increasing fibre diameter was associated with increasing amounts of urine staining. There was also a strong positive phenotypic correlation between clean fleece weight and fibre diameter (0.37 ± 0.05), a phenomenon that has frequently been observed in other flocks.

DISCUSSION

Of the traits that were considered likely to reduce flystrike risk in this flock, wrinkle score was highly heritable but the heritability of urine stain score and dag score were not statistically different from zero. While this research was undertaken, the heritability of wrinkle score was separately investigated in the Western Cape Region of South Africa (0.45 ± 0.13) (Scholtz *et al.,* 2010a), at Armidale in New South Wales, Australia (0.36 ± 0.12) (Smith *et al.,* 2009) and at Mount Barker in Western Australia, Australia (0.45 ± 0.28; Greeff *et al.,* 2009), (0.67 ± 0.07; Greeff *et al.,* 2010). An industry-wide database in Australia (Brown *et al.* 2010) has also yielded a similar estimate of 0.40 ± 0.03. These estimates were relatively close to the New Zealand estimate determined in the Awapiri flock of 0.51 ± 0.11.

Although flystrike was not encountered at Awapiri, breech wrinkle score has been found to be phenotypically correlated with the incidence of breech strike in the Australian studies (Greeff & Karlsson*,* 2009; Greeff *et al.,* 2010; Smith *et al.,* 2009) and also in South Africa (Schotlz *et al.,* 2010a). Greeff *et al.* (2010) reported a relatively strong genetic correlation between dag score and breech strike of 0.42 ± 0.13, which confirms dagginess as a flystrike risk factor in the Western Australian environment. Scholtz *et al.* (2010b) also reported very strong correlations between breech wrinkles and wrinkles on either the neck (0.97 ± 0.30), or body (0.94 ± 0.23) and found that sheep with wrinkles in any of these body regions were more frequently flystruck. Ribby pelts are caused by wrinkles on the body and breech of slaughtered lambs which reduces pelt values (Scobie *et al.,* 2005a). Scobie *et al.* (2005a) estimated the heritability of ribby pelts in New Zealand Merinos at a level only slightly lower than the variety of estimates for breech wrinkle score reported above (0.34 ± 0.18). Scobie *et al.* (2005a; 2005b) also reviewed many of the factors contributing to lower production or higher costs from wrinkly sheep. We therefore have no hesitation in recommending selection against wrinkles either on the breech or on the body.

Urine staining was poorly heritable at Awapiri and although more heritable at Armidale (0.30 ± 0.20; Smith *et al.,* 2009), reports are inconsistent from Mount Barker (0.49 ± 0.32; Greeff & Karlsson*,* 2009), (0.10 ± 0.08; Greeff *et al.,* 2010). All four studies were carried out on different strains of Merino in very different environments and have come up with quite different yet non-significant heritability estimates. At this stage we would therefore not advocate selection on the basis of urine staining. However, given the small proportion of animals which exhibit urine stain, culling urine stained animals may be justified on the phenotypic reduction of wool contamination and reduced labour to control stained wool, without genetic progress.

In the Awapiri flock, the low estimate for the heritability of dag score of 0.08 ± 0.07 was very likely to be due to the fact that dagginess was expressed in very few animals. The estimate was similar to a report from Armidale (0.09 ± 0.06) (Smith *et al.,* 2009), yet different to recent estimates from Western Australia (0.55 ± 0.30; Greeff & Karlsson*,* 2009), (0.41 ± 0.07; Greeff *et al.,* 2010). With such wide variation between estimates from experiments that have been designed to investigate traits that indicate flystrike risk, we should be reluctant to advise selection on dag score. However there is a wealth of evidence which suggests that dag score is heritable, is an indicator of flystrike and internal parasitism. It is therefore worth selecting against daggy sheep.

Interestingly urine stain and dag score were phenotypically correlated (0.24 ± 0.06) but they were not significantly genetically correlated (-0.61 ± 1.29). This makes these two traits intriguing, because we can imagine that the same physical mechanisms might lead to dag formation and urine staining, like the proximity of wool to the source of the contamination. Although the phenotypic relationship was significant, there was no strong evidence to suggest that a genetic predisposition to dagginess was inherited with a genetic predisposition to urine staining in this flock. Of course urine staining of the breech is only expressed in female offspring and with more data, the error term may decrease and we may find a relationship.

Opinions held by sheep breeders suggest that fleece weight increases with wrinkle score. At first glance this appears true for the Awapiri yearlings (Table 5), but when the data are corrected for birth rank and sex this relationship no longer holds with a phenotypic correlation of 0.11 ± 0.06. The genetic association between these two traits was actually negative (-0.35 ± 0.26) although not significant. Along with the live weight measurements from Table 2 we can see how breeders lacking a complete analysis correcting for birth rank, may have been misled by observations suggesting that wrinkly Merinos had heavier fleece weights at shearing. An important point to note is that plain bodied sheep should not be pursued at all cost. Sheep with light fleece weights occur in all wrinkle score groups and these should be culled in favour of animals that produce heavier fleeces. We might also expect that as fleece weight increases, the wool around the breech might be more likely to become stained, but this was not supported by the phenotypic relationship between fleece weight and breech cover (-0.06 ± 0.05) and indeed it was contradicted by the strong negative genetic correlation between these traits of -0.62 ± 0.26. The genetic correlation suggests that as breech cover, or wooliness around the breech increases, fleece weight declines.

Fertility has not been recorded on the yearlings reported here, although a limited number of replacements have had the opportunity to reproduce at the time of writing, the data were not available. Scobie *et al.* (2005a) have previously reported greater fertility of plain bodied sheep in New Zealand Merinos. Supporting evidence was recently reported for South African Merinos (Scholtz *et al.,* 2010a,b). Indeed, Scholtz *et al.* (2010a) found that Merinos which had been experimentally selected for greater fertility were less likely to be flystruck on the breech than a line selected for reduced fertility run in the same flock. This suggests the number of lambs born and weaned will most likely improve without dramatically affecting fleece weight, although the greater number of lambs may grow more slowly and the fleece weight of ewes bearing and rearing multiples may be impaired.

Encouraging genetic and phenotypic correlations were observed between some of the traits which increase flystrike risk. Given the small number of animals in this study, the large parameter estimates with small errors suggest strong relationships. In practice, Awapiri should therefore be able to simultaneously select for decreased wrinkle score and decreased breech cover (or greater breech bareness) without negatively affecting fleece weight. Despite the commercial nature of this flock skewing the data compared with that possible on a research flock, we are confident that this will assist practical application on farm. With particular reference to urine stain, given the evidence collected on this flock we would not recommend selection based on this trait alone. However, given the genetic associations, selecting against wrinkles should decrease urine stain and reduce the amount of wool around the breech which should reduce dag formation.

Although no flystrike was observed on Awapiri, these traits will more than likely improve the flystrike resistance of sheep in the flocks of their ram buying clients. There may be differences between Merino strains and there certainly are differences between environments which might affect the application of this information to other farms. However, given the close agreement between the estimates calculated here and in Australia, on very different strains of Merinos in very different environments, we can strongly recommend selection against wrinkles and against woolly breeches on any farm. Merino farmers can simply walk into the docking pen and identify those that will be guaranteed lower lifetime performance and higher flystrike risk simply by the presence of wrinkles.

ACKNOWLEDGEMENTS

The Ministry of Agriculture and Forestry supported this work through the Sustainable Farming Fund, which was obtained with the help of Merino New Zealand Incorporated and administered by Jon Manhire. The assistance of the Black family from Awapiri in collecting the data and managing the sheep is gratefully acknowledged. Chikako van Koten was very helpful with the biometrical analysis.

REFERENCES

Australian Wool Innovation Ltd., 2007: Visual sheep scores. Australian Wool Innovation Ltd., Sydney, NSW, Australia. 56 pp. www.sheepgenetics.org.au/Document/105/VisualSheepScores.pdf [Accessed: 3 May 2011]

Brown, D.J.; Swan, A.A.; Gill, J.S. 2010: Within- and across-flock genetic relationships for breech flystrike resistance indicator traits. *Animal Production Science* **50:** 1060-1068.

Gilmour, A.R.; Gogel, B.J.; Cullis, B.R.; and Thompson, R. 2009: ASReml User Guide Release 3.0 VSN International Ltd., Hemel Hempstead, Hertfordshire, UK. www.vsni.co.uk

Greeff, J.C.; Karlsson, L.J.E. 2009: Opportunities to breed for resistance to breech strike in Merino sheep in a Mediterranean environment. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics* **18:** 272-278.

Greeff, J.C.; Karlsson, L.J.E.; Schlink, A.C. 2010: Genetic parameters of breech strike and its indicator traits in Merino sheep in a Mediterranean Environment. *Proceedings of the 9th World Congress on Genetics Applied to Livestock Production* **PP4** 157.

James, P.J. 2006: Genetic alternatives to mulesing and tail docking in sheep: a review. *Australian Journal of Experimental Agriculture* **46:** 1-18.

Larsen, J.W.A.; Anderson, N.; Vizard, A.L.; Anderson, G.A.; Hoste, H. 1994: Diarrhoea in Merino ewes during winter: association with trichostrogylid larvae. *Australian Veterinary Journal* **71:** 365-372.

Leathwick, D.M.; Atkinson, D.S. 1995: Dagginess and flystrike in lambs grazed on *Lotus corniculatus* or ryegrass. *Proceedings of the New Zealand Society of Animal Production* **55:** 196-198.

Leathwick, D.M.; Atkinson, D.S. 1996: Influence of different proportions of *Lotus corniculatus* in the diet of lambs on dags, flystrike and animal performance. *Proceedings of the New Zealand Society of Animal Production* **56:** 99-102.

Scholtz, A.J.; Cloete, S.W.P.; van Wyk, J. B.; Kruger, A.C.M.; de K.van der Linde, T. C. 2010a: Influence of divergent selection for reproduction on the occurrence of breech strike in mature merino ewes. *Animal Production Science* **50:** 203-209.

Scholtz, A.J.; Cloete, S.W.P.; van Wyk, J.B.; Misztal, I.; du Toit, E.; de K.van der Linde, T.C. 2010b: Genetic (co)variances between wrinkle score and absence of breech strike in mulesed and unmulesed Merino sheep, using a threshold model. *Animal Production Science* **50:** 210-218.

Scobie, D.R.; O'Connell, D.; Bray, A.R.; Cunningham, P. 2002: Breech strike can be reduced by increased area of naturally bare skin around the perineum of lambs. *Proceedings of the Australian Society of Animal Production* **24:** 201-204.

Scobie, D.R.; Young, S.R.; O'Connell, D.; Eythorsdottir, E. 2005a: Skin wrinkles of the sire adversely affect Merino and halfbred pelt characteristics and other production traits. *Australian Journal of Experimental Agriculture* **45:** 1551-1557.

Scobie, D.R.; Young, S.R.; O'Connell, D.; Gurteen, S. 2005b: Skin wrinkles affect wool characteristics and the time taken to harvest wool from Merino and Halfbred sheep. *New Zealand Journal of Agricultural Research* **48:** 177-185.

Scobie, D.R.; O'Connell, D.; Morris, C.A.; Hickey, S.M. 2007: A preliminary genetic analysis of breech and tail traits with the aim of improving the welfare of sheep. *Australian Journal of Agricultural Research* **58:** 161-167.

Scobie, D.R.; O'Connell, D.; Morris, C.A.; Hickey, S.M. 2008: Dag score is negatively correlated with breech bareness score of sheep. *Australian Journal of Experimental Agriculture* **48:** 999-1003.

Scobie, D.R.; O'Connell, D. 2010: Breech bareness reduces flystrike in New Zealand crossbred sheep. *Animal Production Science* **50:** 599-602.

Smith, J.L.; Brewer, H.G.; Dyall, T. 2009: Heritability and phenotypic correlations for breech strike and breech strike resistance indicators in Merinos. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics* **18:** 334-337.

Walker, G.; Young, M. 2009:http://www.sheepimprovement.co.nz/getdoc/a9bb121b-2016-4b34-a163-399ae4b28471/Doc-ID-000010-GW-Bare-Points-Sheep.aspx